Project C-6: Doped carbon nanotubes for hydrogen storage

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This research is focused on modifying carbon nanotubes systems in an attempt to enhance and tune the hydrogen storage capabilities of the nanotubes. The objective of this research has been to introduce transition metals and hydrogen bonding clusters into tubes. The intent is aimed at producing consistent size dopants and structures of carbon nanotubes. The success of making doped carbon nanotubes with transition metals and alloys can allow for a weak covalent bond similar to cases of dihydrogen bond that is not restricted to purely physisorption or chemisorption]. Controlling the type and size of tubes and dopant is expected to tune the product for hydrogen sorption to occur at desired temperature and pressure.

Approach

Our research is focused on modifying carbon nanotubes by doping them with different atoms and encapsulating metal clusters inside the tubes to make them suitable for hydrogen storage. Relying on physisorption alone will lead to a too weak bond and chemisorption will lead to a too strong bond. Therefore, our objective is to establish a weak covalent bond where the electron donation from the σ^* orbital of hydrogen to the doped tubes weakens but does not break the hydrogen-hydrogen bond.

The method of producing doped carbon nanotubes with controlled characteristics is a method developed at SRTC and is in the process of being patented. Thermodynamic characterization of hydrogen uptake and release was conducted. Different spectroscopic methods are applied to identify the type and size of nanotubes and clusters that could result in a reversible, high hydrogen-capacity material.

Results

The synthesis of different doped carbon nanotubes has been achieved, using SRTC technique that allowed for controlling the type and amount of dopants in the tubes. It was possible to produce (tens of grams) quantities of consistent structure carbon nanotube systems. Preliminary results of hydrogen sorption showed 1 %, by weight, hydrogen uptake and release at one atmosphere and over a temperature range of 50 to 250° C. A thermogravimetric (TGA) system capable of operating at a wide range of temperatures was used to measure hydrogen uptake and release. Nitrogen-doped carbon nanotubes, with average nitrogen content of about 5 wt. %, were also synthesized.